

**CLAIMS:**

1. A method for generating a quantitative face direction from a single digital image of a person's face, said method including the steps of:
  - 5 computing the rotation of a face in said image dependent upon a nose axis of said face;
  - computing the tilt of said face in said image; and
  - determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face.
- 10 2. The method according to claim 1, further including the step of determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.
- 15 3. The method according to claim 2, wherein said nose-axis determining step further includes the step of comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.
- 20 4. The method according to claim 3, wherein said nose axis determining step applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.
- 25 5. An apparatus for generating a quantitative face direction from a single digital image of a person's face, said apparatus including:
  - means for computing the rotation of a face in said image dependent upon a nose axis of said face;
  - means for computing the tilt of said face in said image; and
  - 30 means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face.

6. The apparatus according to claim 5, further including means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

5 7. The apparatus according to claim 6, wherein said nose-axis determining means further includes means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

10 8. The apparatus according to claim 7, wherein said nose axis determining means applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.

15 9. A computer program product having a computer usable medium having a computer readable program code means embodied therein for generating a quantitative face direction from a single digital image of a person's face, said computer program product including:

20 computer readable program code means for computing the rotation of a face in said image dependent upon a nose axis of said face;

computer readable program code means for computing the tilt of said face in said image; and

25 computer readable program code means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face.

30 10. The computer program product according to claim 9, further including computer readable program code means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

11. The computer program product according to claim 10, wherein said computer readable program code means for determining said nose axis further includes computer readable program code means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

12. The computer program product according to claim 11, wherein said computer readable program code means for determining said nose axis applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.

13. A method for establishing a facial gesture from a sequence of face images, based on changes of face direction, said method including the steps of:  
for each image, generating a quantitative face direction from a respective image, said generating step including the sub-steps of:  
    computing the rotation of a face in said image  
    dependent upon a nose axis of said face;  
    computing the tilt of said face in said image; and  
    determining said quantitative face direction of said face  
    in said image dependent upon said rotation and said tilt of said face;  
determining face direction changes using said quantitative face directions of said face images and applying labels to said changes; and  
parsing said sequence of labels to determine said facial gesture.

14. The method according to claim 13, further including the step of determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

15. The method according to claim 14, wherein said nose-axis determining step further includes the step of comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

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16. An apparatus for establishing a facial gesture from a sequence of face images, based on changes of face direction, said apparatus including:

means for, for each image, generating a quantitative face direction from a respective image, said generating means further including:

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means for computing the rotation of a face in said image dependent upon a nose axis of said face;

means for computing the tilt of said face in said image;

and

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means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;

means for determining face direction changes using said quantitative face directions of said face images and applying labels to said changes; and

means for parsing said sequence of labels to determine said facial gesture.

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17. The apparatus according to claim 16, further including means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

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18. The apparatus according to claim 17, wherein said nose-axis determining means further includes means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

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19. A computer program product having a computer usable medium having a computer readable program code means embodied therein for establishing a

facial gesture from a sequence of face images, based on changes of face direction, said computer program product including:

computer readable program code means for, for each image, generating a quantitative face direction from a respective image, said computer readable program code means  
5 for generating further including:

computer readable program code means for computing  
the rotation of a face in said image dependent upon a nose axis  
of said face;

computer readable program code means for computing  
10 the tilt of said face in said image; and

computer readable program code means for determining  
said quantitative face direction of said face in said image  
dependent upon said rotation and said tilt of said face;

computer readable program code means for determining face direction  
15 changes using said quantitative face directions of said face images and applying labels  
to said changes; and

computer readable program code means for parsing said sequence of labels to  
determine said facial gesture.

20 20. The apparatus according to claim 19, further including computer  
readable program code means for determining said nose axis by maximizing a  
correlation measure between a left side and a right side of said face from left and right  
sub-images of said image.

25 21. The apparatus according to claim 20, wherein said computer readable  
program code means for determining said nose axis further includes computer  
readable program code means for comparing one of said left and right sides with a  
synthetic side derived from the other of said left and right sides using symmetry and a  
perspective transformation of said other side to compute said correlation measure.

22. A method of providing a visual mouse to detect a quantitative face direction as an interface for a computer application from a single digital image of a person's face, said method including the steps of:

5       computing the rotation of a face in said image dependent upon a nose axis of  
said face;  
      computing the tilt of said face in said image; and  
      determining said quantitative face direction of said face in said image  
dependent upon said rotation and said tilt of said face;  
      providing said quantitative face direction as input to said computer  
10   application.

23. The method according to claim 22, further including the step of  
determining said nose axis by maximizing a correlation measure between a left side  
and a right side of said face from left and right sub-images of said image.

15       24. The method according to claim 23, wherein said nose-axis determining  
step further includes the step of comparing one of said left and right sides with a  
synthetic side derived from the other of said left and right sides using symmetry and a  
perspective transformation of said other side to compute said correlation measure.

20       25. The method according to claim 24, wherein said nose axis determining  
step applies a contrast enhancement algorithm to a nose region of said image, wherein  
said nose is the part of a face that reflects the most light, said reflected light being  
represented as a line-like region close to a real nose axis.

25       26. An apparatus for providing a visual mouse to detect a quantitative face  
direction as an interface for a computer application from a single digital image of a  
person's face, said apparatus including:

      means for computing the rotation of a face in said image dependent upon a  
30   nose axis of said face;  
      means for computing the tilt of said face in said image; and

means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;

means for providing said quantitative face direction as input to said computer application.

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27. The apparatus according to claim 26, further including means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

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28. The apparatus according to claim 27, wherein said nose-axis determining means further includes means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

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29. The apparatus according to claim 28, wherein said nose axis determining means applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.

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30. A computer program product having a computer usable medium having a computer readable program code means embodied therein for providing a visual mouse to detect a quantitative face direction as an interface for a computer application from a single digital image of a person's face, said apparatus including:

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computer readable program code means for computing the rotation of a face in said image dependent upon a nose axis of said face;

computer readable program code means for computing the tilt of said face in said image; and

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computer readable program code means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;

computer readable program code means for providing said quantitative face direction as input to said computer application.

31. The computer program product according to claim 30, further  
5 including computer readable program code means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

32. The computer program product according to claim 31, wherein said  
10 computer readable program code means for nose-axis determining further includes computer readable program code means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

15 33. The computer program product according to claim 32, wherein said computer readable program code means for nose axis determining applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like  
20 region close to a real nose axis.

34. A method of video-conferencing providing eye-to-eye contact communication using a quantitative face direction from a single digital image of a person's face, said method including the steps of:  
25 computing the rotation of a face in said image dependent upon a nose axis of said face;  
computing the tilt of said face in said image; and  
determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;  
30 providing said quantitative face direction as input to said computer application.



35. The method according to claim 34, further including the step of determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

5           36. The method according to claim 35, wherein said nose-axis determining step further includes the step of comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using symmetry and a perspective transformation of said other side to compute said correlation measure.

10           37. The method according to claim 36, wherein said nose axis determining step applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.

15           38. An apparatus for video-conferencing providing eye-to-eye contact communications using a quantitative face direction from a single digital image of a person's face, said apparatus including:

              means for computing the rotation of a face in said image dependent upon a nose axis of said face;

20           means for computing the tilt of said face in said image; and

              means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;

              means for providing said quantitative face direction as input to said computer application.

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              39. The apparatus according to claim 38, further including means for determining said nose axis by maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

30           40. The apparatus according to claim 39, wherein said nose-axis determining means further includes means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using

symmetry and a perspective transformation of said other side to compute said correlation measure.

41. The apparatus according to claim 40, wherein said nose axis  
5 determining means applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.

42. A computer program product having a computer usable medium  
10 having a computer readable program code means embodied therein for video-conferencing providing eye-to-eye contact communications using a quantitative face direction from a single digital image of a person's face, said apparatus including:

computer readable program code means for computing the rotation of a face in said image dependent upon a nose axis of said face;

15 computer readable program code means for computing the tilt of said face in said image; and

computer readable program code means for determining said quantitative face direction of said face in said image dependent upon said rotation and said tilt of said face;

20 computer readable program code means for providing said quantitative face direction as input to said computer application.

43. The computer program product according to claim 42, further  
including computer readable program code means for determining said nose axis by  
25 maximizing a correlation measure between a left side and a right side of said face from left and right sub-images of said image.

44. The computer program product according to claim 43, wherein said  
computer readable program code means for nose-axis determining further includes  
30 computer readable program code means for comparing one of said left and right sides with a synthetic side derived from the other of said left and right sides using

symmetry and a perspective transformation of said other side to compute said correlation measure.

- 5        45.     The computer program product according to claim 44, wherein said computer readable program code means for nose axis determining applies a contrast enhancement algorithm to a nose region of said image, wherein said nose is the part of a face that reflects the most light, said reflected light being represented as a line-like region close to a real nose axis.